KNOXVILLE LOCOMOTIVE WORKS, INC. – C. Choi

COMPANY OVERVIEW

- ***Knoxville Locomotive Works, Inc. (KLW)*** was originally established by Gulf & Ohio Railways, Inc. to serve as a maintenance company for the G&O family of railroads. Upon upgrade completion of the G&O fleet, KLW performed locomotive maintenance and modifications of Class I units on a contract basis. In 2010, KLW evolved into a remanufacturer of 'green' locomotives.

1998

KLW Incorporation

2017

KLW attains EPA Tier 4 Certification for switch and line-haul locomotives.

2019

KLW attains California Air Resources Board (CARB) Tier 4 Verification.

2023

Since 2015 KLW has manufactured and delivered more than fifty Tier 4 locomotives across the U.S.

N.A. Rail Overview

Equipment interoperable between 3 countries
- 140,000 miles of privately owned track

Class I Railroads
- 6 Railroads
- 68% of freight rail mileage
- 88% of Rail employees
- 95% of revenue

Class II and III
- 615 short line railroads
- 44,000 route miles

Passenger Rail
- Operates on more than 21,000 miles
- Amtrak owns ~655 miles

Switching and Terminals
- Small railroads the pick-up and deliver goods
- Moves traffic between larger railroads

Ref: Association of American Railroads

Freight Rail

Account for roughly 40% of U.S. long-distance freight volume (measured by ton-miles)

Haul farm and food products moved in a year
1.6 million carloads of grain and other farm products
>1.7 million carloads of food products
Over 1/3 of U.S. grain export movements

Movement of Construction, Pulp & Paper
More than two million carloads of construction-related materials in a typical year
Carries ~700,000 carloads of pulp and paper products

Motor Vehicles & Parts
Carries 1.5 million carloads in a typical year
Transports ~75% of the new cars and light trucks purchased in the U.S.

Intermodal:
In 2023, U.S. rail intermodal volume was 12.7 million units
Accounted for ~ 25% of revenue for major U.S. railroads
Fastest-growing major rail traffic segment over the past 25 years
Half of rail intermodal volume consists of imports or exports

US Freight Efficiency

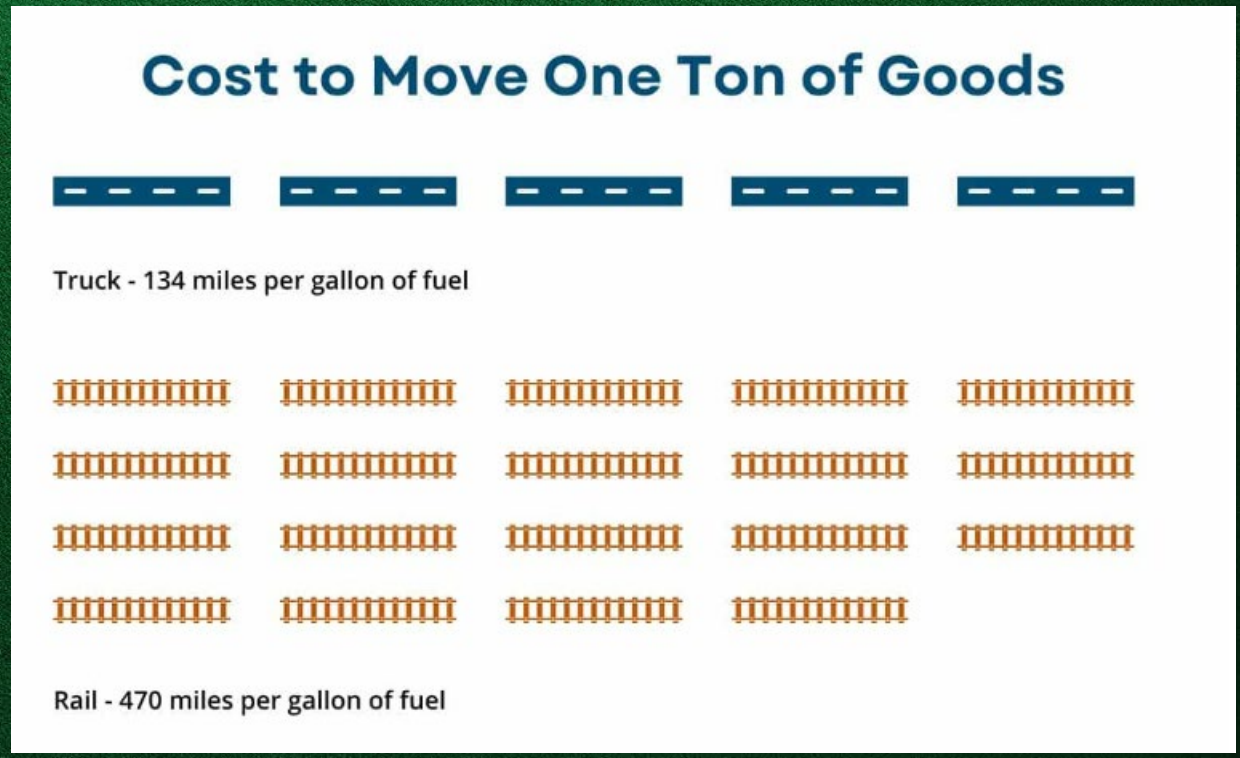
Summary of Rail Movement Characteristics and Results

Ref: Federal Railroad Administration, Final Report Comparative Evaluation of Rail and Truck Fuel Efficiency on Competitive Corridors November 19, 2009

Movement	Equipment Type*	Distance (miles)	Grade Severity	HP per Trailing Ton	Average Speed (mph)	Payload (tons)**	Fuel Efficiency (ton-miles/ gallon)	Rail-Truck FE Ratio
1	BC	280	1.7	1.1	14	66	406	3.9
2	DS	294	1.8	1.5	31	38	384	5.5
3	G	133	1.3	1.9	31	73	301	2.3
4	BC	1,083	1.9	1.2	21	74	469	3.6
5	G	242	2.2	2.0	17	96	278	2.8
6	TOFC	790	2.0	1.6	27	15	273	3.2
7	CH	790	2.0	1.3	21	98	487	5.3
8	DS	352	1.4	1.4	31	30	373	5.5
9	CH	352	1.4	1.4	21	95	475	4.3
10	A	367	1.4	1.4	27	18	156	1.9
11	A	561	1.8	1.4	20	18	157	2.0
12	G	910	2.1	1.3	21	91	452	4.0
13	DS	450	2.2	1.9	31	30	226	2.7
14	DS	673	1.5	2.1	50	54	348	3.5
15	DS	1,415	2.0	2.7	45	69	361	3.9
16	DS	2,232	2.6	2.2	46	65	426	4.8
17	A	445	1.5	2.0	51	20	164	2.2
18	DS	1,805	2.0	1.7	39	70	449	4.6
19	DS	2,090	2.6	2.5	44	48	358	4.0
20	DS	1,034	1.5	1.6	41	50	512	5.1
21	DS	2,150	2.6	2.1	48	54	409	4.5
22	DS	1,484	1.7	1.7	37	39	490	5.2
23	TC	1,788	2.6	2.3	43	47	370	5.3

* A = Auto Rack; BC = Box Car; CH = Covered Hopper; DS = Double-stack; G = Gondola; TC = Tank Car; TOFC = Trailer on Flat Car

** Rail and truck payloads are different due to different equipment capacities. Rail payload for intermodal movements are based on two stacked containers.



Ref: RSI Logistics

DIESEL LOCOMOTIVE TECHNOLOGY BREAKTHROUGHS - History

Pre-2024 (not in chronological order)	2024 +
Automatic Transition	
Dynamic Brake	

Ref: Trains Magazine, “8 Diesel Locomotive Breakthroughs” March/May 2024

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Interoperability and Challenges

Rail Interoperability

- Guided by the Association of American Railroads
- Different railway systems working together safely and without interruption
- Ensures trains, infrastructure, and control systems from different regions can operate without compatibility issues[1]
- DOT FRA regulates interoperability standards
    - The Rail Safety Improvement Act of 2008 (RSIA) mandated the implementation of Positive Train Control (PTC) systems on Class 1 railroads' main lines over which five million or more gross tons of annual traffic and certain hazardous materials are transported, and on any main lines over which intercity or commuter rail passenger transportation is regularly provided.[2]

Summary challenges for new, reduced GHG locomotives:
Class 1 Railroads have set ambitious goals to reduce GHG by 2030[3]

Ref: [1]Global Railway Review, [2] DOT FRA, [3]Railway Age "The Clock is Ticking: Railroads and the Net-Zero 2050 Goal"

Interoperability and Challenges

Summary challenges for new, reduced GHG locomotives: Class 1 Railroads have set ambitious goals to reduce GHG by 2030[3]

- Railroads need ~15 years or more to fully transition to interoperable net-zero locomotives that includes supporting infrastructure and facilities → running out of time to test technologies and implement transition plan[3]
- Tier 4 models have yet to prove sufficient value proposition in light of the various alternative energy sources under discussion → railroads choosing to rebuild[3]

SCIENCE BASED TARGETS
DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

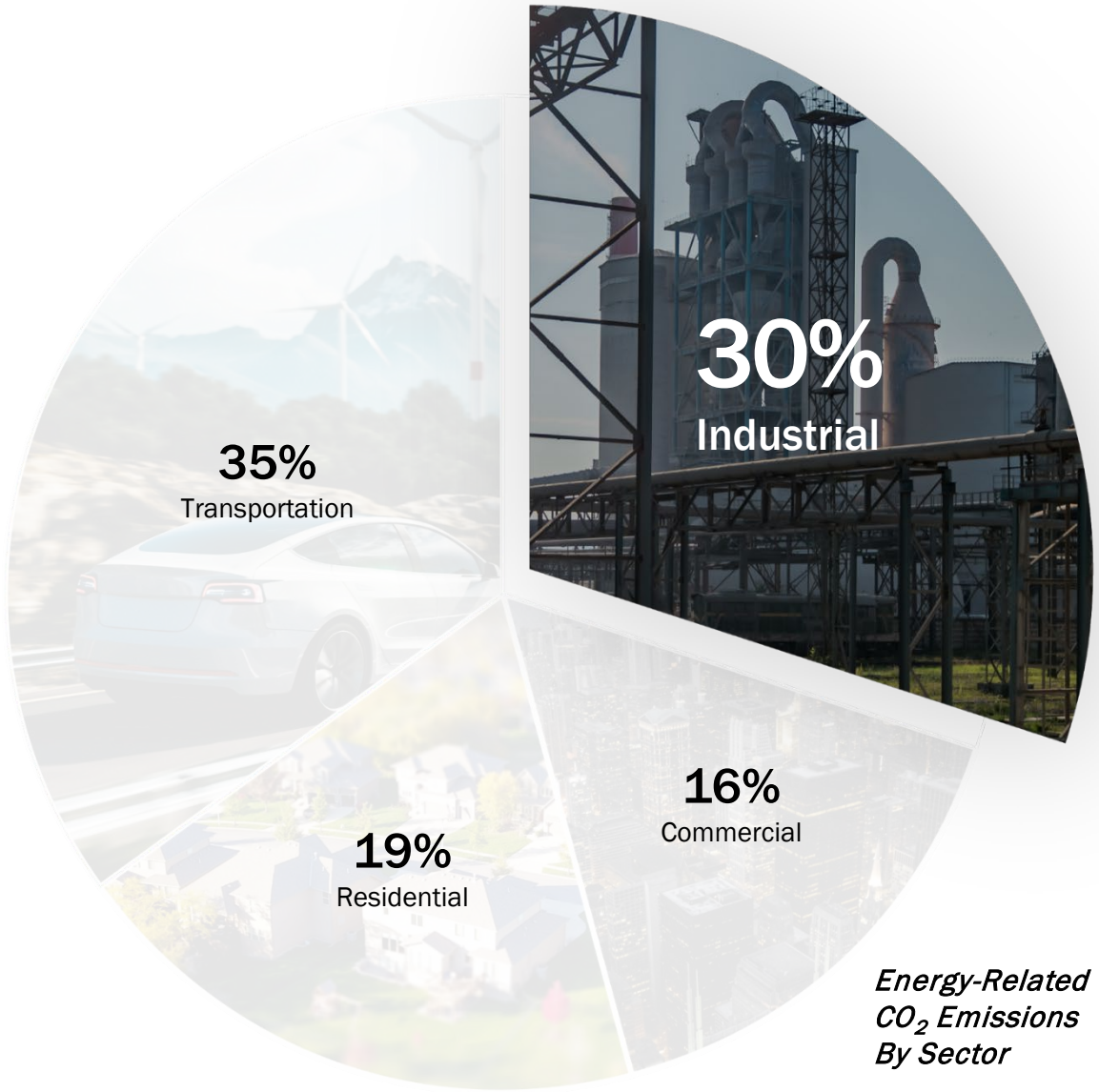
Near term | Long term | Net-zero | Location | North America × | Organisation type | Ground Transportati... × | Date

COMPANY/FINANCIAL INSTITUTION	TARGETS: NEAR TERM	Goal Type	Amount	NET-ZERO
BNSF Railway United States of America (USA), North America	COMMITTED	Absolute	30%	-
Canadian National Railway Company Canada, North America	WELL-BELOW 2°C	Intensity	43%	COMMITTED
Canadian Pacific Railway Company Canada, North America	WELL-BELOW 2°C	Intensity	38%	-
CSX Corporation United States of America (USA), North America	WELL-BELOW 2°C	Intensity	37%	-
Norfolk Southern Corporation United States of America (USA), North America	WELL-BELOW 2°C	Intensity	42%	-
Union Pacific Railroad United States of America (USA), North America	WELL-BELOW 2°C	Absolute	26%	Announced Intent
Kansas City Southern United States of America (USA), North America	WELL-BELOW 2°C	Intensity	42%	-

Source: https://sciencebasedtargets.org/companies-taking-action

Ref: [1]Global Railway Review, [2] DOT FRA, [3]Railway Age "The Clock is Ticking: Railroads and the Net-Zero 2050 Goal"

U.S. Industrial GHG Emissions

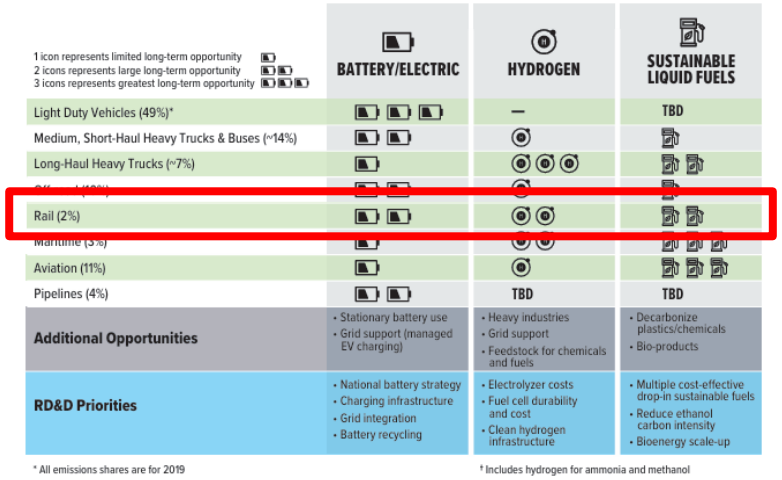


Energy-Related CO_2 Emissions By Sector

Industrial sector is comprised of
manufacturing | agriculture | mining | construction

EIA, *Annual Energy Outlook 2020 with Projections to 2050*. Source: Industrial Decarbonization Roadmap.

THE U.S. NATIONAL BLUEPRINT FOR TRANSPORTATION DECARBONIZATION
Net Zero 2050 - Priority actions to decarbonize rail



1 icon represents limited long-term opportunity
2 icons represents large long-term opportunity
3 icons represents greatest long-term opportunity

	BATTERY/ELECTRIC	HYDROGEN	SUSTAINABLE LIQUID FUELS
Light Duty Vehicles (49%)*		–	TBD
Medium, Short-Haul Heavy Trucks & Buses (~14%)			
Long-Haul Heavy Trucks (~7%)			
[illegible]			
Rail (2%)			
Maritime (3%)			
Aviation (11%)			
Pipelines (4%)		TBD	TBD
Additional Opportunities	• Stationary battery use • Grid support (managed EV charging)	• Heavy industries • Grid support • Feedstock for chemicals and fuels	• Decarbonize plastics/chemicals • Bio-products
RD&D Priorities	• National battery strategy • Charging infrastructure • Grid integration • Battery recycling	• Electrolyzer costs • Fuel cell durability and cost • Clean hydrogen infrastructure	• Multiple cost-effective drop-in sustainable fuels • Reduce ethanol carbon intensity • Bioenergy scale-up

* All emissions shares are for 2019

† Includes hydrogen for ammonia and methanol

<u>Infrastructure investments</u>

- Interoperability and infrastructure for clean fuel technology adoption
- Build strong domestic rail equipment supply chains for electric and alternatively fueled locomotives
- Support the development and deployment of sustainable fuels.

<u>Multi-stakeholder collaborations</u>

- Ambitious and shared targets and regulation for the rail sector
- Existing industry partnerships designed to improve efficiency and reduce emissions in the freight network.
- State freight advisory committees to help transition fleets and modernize rail systems.

<u>Research and innovation</u>

- Advance technology through pilot projects
- Policy/regulation support → accelerate the growth of electrification of the U.S. passenger rail
- Prioritize freight rail research for promising paths to decarbonization
  - ✓ Sustainable fuels, design and manufacture of new locomotive propulsion and fueling systems.
- Identify transformative pathways to inform the development of ambitious goals and regulation to reduce rail emissions.
- Collection of real-world operational data to understand vehicle requirements and develop models and tools to identify the most viable clean technology solutions to replace diesel locomotives.

KLW SUSTAINABILITY: Current and Future Technologies

Biodiesel & Renewable Fuels

- Run 100% renewable diesel and 20% biodiesel in existing locomotives, which can quickly reduce carbon emissions by 20-25%.
- Dual Fuel Engines – Allows diesel fueled engines transition to lower carbon fuels.
- Interoperability – Allows renewable, low carbon fuels to be used when available and provides diesel fuel as a secondary source of fuel.

KLW SUSTAINABILITY: Current and Future Technologies

Battery Electic Hybrid Locomotives

- Testing and demonstrating hybrid battery- powered line-haul and switching locomotives to meet intensive rail operation demands.

Zero Emissions

- Zero emissions for both switcher and line-haul locomotives are in development.

Challenges with 100% Battery Electric and/or Catenary for long haul Rail freight

- ❑ Battery weight impacts cargo carrying capacity
- ❑ Catenary installation estimated cost $2m to $4.8m per track mile, depending on the source
- ❑ Available renewable energy to power long haul catenary

DIESEL LOCOMOTIVE TECHNOLOGY BREAKTHROUGHS - Now & Future

Pre-2024

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AC Traction Motors

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2024 +

Focus on improving efficiency!

- Engine Systems
  - Fuel efficiency for lower GHG
  - Engine + Energy Storage Hybrid

Critical enablers

- High power electronics efficiency
- Traction motor (more tractive power in smaller space)
- Next generation controls
  - Power Distribution
- Thermal Management

Modular design

→ Technology Demonstrations for alternative powertrains

→ Ongoing input from Rail to Departments

THANK YOU